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ABSTRACT

Effects of Logo instruction on the performance of 21 grade 2 and 26 grade 4 Canadian students on a map reading task was examined in a pretest-treatment-posttest design with controls. Logo instruction was implemented through a series of four graduated, sequential Logo Microworld programs which were used by students daily for 7 months. The control group consisted of children drawn from classes in which computers were used for drills and word processing. The pretest-posttest map-reading task required children to give instructions to a puppet about how to proceed along the paths of 12 maps. Findings indicated that (1) the acquisition of basic Logo concepts involving use of alternative frames of reference and the manipulation of directions involving rotation and angles can be facilitated through the implementation of the Logo Microworld programs; (2) the careful implementation of the Microworld programs resulted in transfer of specific spatial skills to the related domain of map-reading; and (3) developmental constraints exist that limit the ability of young children to master certain spatial skills embedded in Logo and to use them in contexts involving transfer. It is concluded that findings highlight the importance of carefully matching concepts in Logo with specific cognitive effects and of taking into consideration task complexity and cognitive developmental factors. (RH)

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TRANSFER OF SPATIAL CONCEPTS * FROM LOGO TO MAP-READING

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A B S T R A C T

So far reports on the cognitive effects of computer programming have been contradictory. We tested the hypothesis that before attempting to measure Logo effects on general problem solving skills one should be able to demonstrate Logo effects on specific problem solving tasks which share common elements with Turtle Geometry. The effects of Logo instruction on the performance of grade 2 and 4 children on a map-reading task was examined within a pretest-treatment-posttest design with controls. Logo instruction was implemented through a series of four graduated Logo Microworlds used by children daily for seven months. The control group consisted of children drawn from classes in which computers were used for drills and word-processing.

The map-reading task required children to give instructions to a puppet on how to proceed along the paths of 12 maps. Their directions were analyzed for accuracy on right/left turns from various orientations.

Covarying for pretest scores, there was a significant grade and treatment effect: grade 4 outperformed grade 2 children, and the experimental group outperformed the control group. There was also a highly significant grade-by-treatment interaction reflecting the improvement in the experimental grade 4 group on items involving rotated right/left turns and acute turns.

We conclude that by gradually presenting Turtle Geometry concepts to children it is possible to alleviate heavy processing demands embedded in "standard" Logo and to automatize basic Logo building blocks. These specific skills can then be transferred to related areas.

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A I M S

The study was set to answer the following questions:

1. Does the use of the graduated series of Logo Microworlds facilitate comprehension of basic concepts in Turtle Geometry (e.g. right/left turns; manipulation of rotated/non rotated angles)?

2. Does the use of the Logo microworlds facilitate transfer of spatial concepts to related domains such as map reading?

3. How do grade 2 and 4 children compare with regard to questions 1 and 2?

M E T H O D

Subjects

The experimental group consisted of 21 grade 2 and 26 grade 4 children randomly drawn from two grade 2 and two grade 4 classes in four schools located in a working class neighbourhoods. The control group consisted of a fairly similar group of children drawn from two additional schools in which computers were used for various reading and math drills and word processing.

Treatment

The Logo Microworlds

The Microworlds (Magic Room, Turtle The Count, The Turtle Factory, Peter Pan Turtle) were designed by analyzing prerequisite skills and cognitive demands, and each microworld forms an extension of the one preceding it in the series.

To encourage use of measurement, the screen boundaries are visually represented as rulers, marked with visible units of distance, or "Turtle steps" (each equal to ten regular Logo units).

Since young beginners often experience difficulty with right and left turn commands, we start them off by exploring Turtle movement in an absolute frame of reference (i.e., the Turtle never changes its heading and can only move up, down or sideways). Only with the

fourth Microworld, Peter Pan Turtle, is the child introduced to movement in a relative frame of reference (i.e., movement with respect to the Turtle's current heading) as used in Turtle Geometry.

In Magic Room no numeric inputs are used with the commands. These are introduced in the second numeric Microworld, Turtle the Count. Three ready-made shapes (square, circle and triangle), colour filled or hollow, are available allowing the young child to create meaningful configurations. In the Turtle Factory an interactive REPEAT command enables the child to generate pre-planned recurring patterns. The Peter Pan Microworld gradually introduces children to non-numeric (fixed) right and left 90d and 30d turns and allows the child the opportunity to explore pivotal movement as well as movement in a relative frame of reference. To facilitate the development of angle and rotation concepts the Turtle rotates in slow motion.

Logo Instruction

Logo instruction extended for seven months. In each class there were four computers allowing each child 2 - 2 1/2 hours of weekly contact with the Logo microworlds. Logo instruction involved guided use of the four-microworld series alternating between free exploration and gentle coaching by teachers and project staff. It also included a variety of off computer games and tasks focussing on planning, sequencing and debugging skills. Children were allowed to progress from one microworld to the next at their own pace, with built in computer tasks ("challenges") designed to access children's readiness to progress to a more complex module. Over the year children spent 65-70 hours on the Logo Microworlds. Grade 4 children explored only the first 3 Microworlds while grade 4 children explored the whole series.

Map Reading

This task was individually administered to all children as a pretest in the fall, and as a posttest at the end of the school year. It consisted of 12 maps with 90d and 45d turns (see Figure 1). The number of right/left turns from different orientations were counterbalanced. Children's directions to a puppet on how to proceed from "start" to "end" were tape-recorded and analyzed for accuracy in marking right/left turns from different orientations and the extent to which they attempted to express a distinction between straight and acute angles.

RESULTS

Since the range of intercorrelations among subtests consisting of items involving a) 180d rotation, b) 90d rotation and c) acute turns was 0.62 to 0.84, the sum of these three subtests, entitled ROTATE, was defined as an additional score variable. It should be noted that for the experimental group the correlation between a Logo learning task (see Geva and Cohen, 1987) and the posttest ROTATE scores was 0.32 ($p<.05$); it was 0.26 ($p<.05$) with the TURN score (which consisted of right/left turns without rotation). The Hoyt estimate of internal consistency was 0.95 for the map-reading pretest and 0.96 for the posttest.

Using a repeated measures design a multiple analysis of variance was applied to the data with grade (2, 4), and treatment (experimental/control) as between factors, and time (pretest/posttest) and subtest map-reading scores as within subject variables. There was a significant effect for grade on each of the subtests as well as the TOTAL score and the ROTATE score ($F(2,79)=27.95$, $p<.001$). Grade 4 children outperformed grade 2 children. There was also a significant main effect for time ($F(1,79)=4.07$, $p<.05$) and two significant interactions involving time: treatment by time ($F(1,79)=10.75$, $p<.002$) and treatment by grade by time ($F(1,79)=10.18$, $p<.002$). These interactions reflect the big jump in the grade 4 experimental group from pretest to posttest on the ROTATE scores. An additional analysis in which pretest scores were covaried did not change this pattern of results. There were also two significant interactions involving subtests: grade by subtest ($F(2,158)=5.27$, $p<.05$) and grade by time by subtest ($F(2,158)=3.49$, $p<.05$). Post-hoc comparisons revealed that these latter interactions may be attributed to an improvement in the experimental grade 2 groups on the TURN items which did not involve rotation (see Figure 2), as well as an improvement in the grade 4 experimental group on the ROTATE items (see Figure 3). These results are summarized in TABLE 1.

CONCLUSIONS

The significant improvement in the ability of the younger grade 2 children to distinguish right/left when there is a correspondence between the child's right/left and those of the puppet can be attributed to the ample opportunities to issue explicit direction commands to the Turtle in the first three Microworlds. In these Microworlds Turtle movement is possible only within an absolute frame of reference.

The most striking improvement took place in the grade 4 experimental group. These children had an opportunity to become aware of the distinction between using their ego as a frame of reference and using the Turtle as a frame of reference when they progressed from the first three Microworlds in the series to the PETER PAN Microworld.

The task analytic approach used to design the series of Microworlds was compatible with children's need to master prerequisite skills embedded in the Logo language before introducing them to higher level problem solving skills.

In the present study we showed that:

1. The acquisition of basic Logo concepts involving use of alternative frames of reference and the manipulation of directions involving rotation and angles can be facilitated through the implementation of the Logo Microworlds.

2. The careful implementation of these Microworlds resulted in transfer of specific spatial skills to a related domain such as map-reading.

3. There are developmental constraints that limit the ability of young children to master certain spatial skills embedded in Logo and to use them in related domains and skills that are to be transferred.

Results of this study highlight the importance of carefully matching concepts in Logo with specific cognitive effects and of taking into consideration task complexity and cognitive developmental factors.

Figure 1: Examples of Map-Reading Task

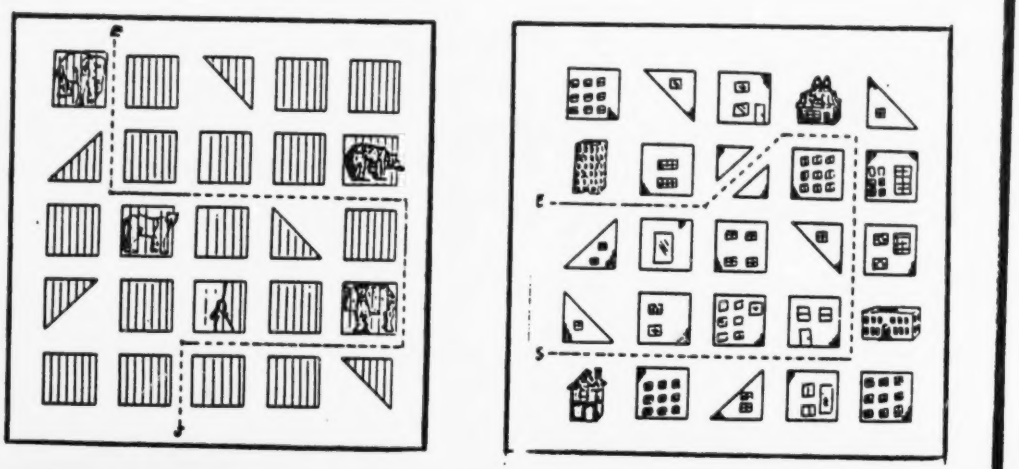

TABLE 1: Map Reading Pretest and Posttest Subtest Means and Standard Deviations by Grade and Treatment (in percentages)

		Experimental		Control	
		Grade 2 (n=22)	Grade 4 (n=23)	Grade 2 (n=21)	Grade 4 (n=21)
Pretest					
Start[1]	$\bar{X}$	35.0	40.0	13.3	26.0
	SD	39.0	36.0	28.7	33.0
Turn[2]	$\bar{X}$	58.5	80.0	58.1	78.0
	SD	43.1	10.3	44.6	13.6
Rotate[3]	$\bar{X}$	11.6	23.8	16.6	45.2
	SD	12.0	10.8	19.9	40.0
Posttest					
Start	$\bar{X}$	31.0	9.0	24.3	14.0
	SD	42.2	19.0	39.9	36.0
Turn	$\bar{X}$	73.5	91.0	64.3	71.0
	SD	37.0	11.8	40.7	12.6
Rotate	$\bar{X}$	12.0	52.4	16.7	38.2
	SD	18.2	29.4	23.0	31.5

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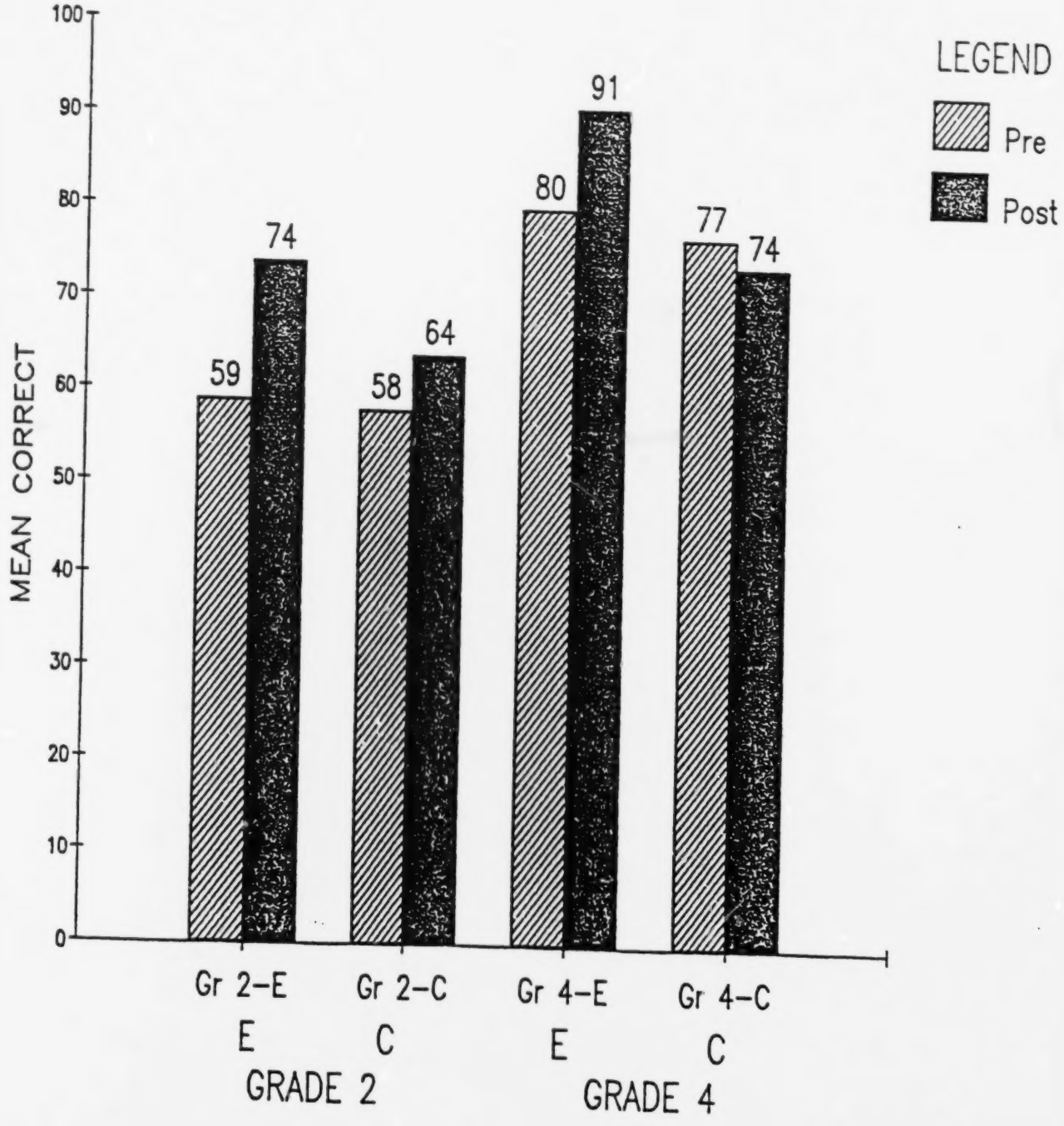
[1] Start: 10 items referring to non-rotated starting positions on trail.

[2] Turn: 10 items referring to non-rotated right/left turns. Child's right/left corresponds to those of puppet.

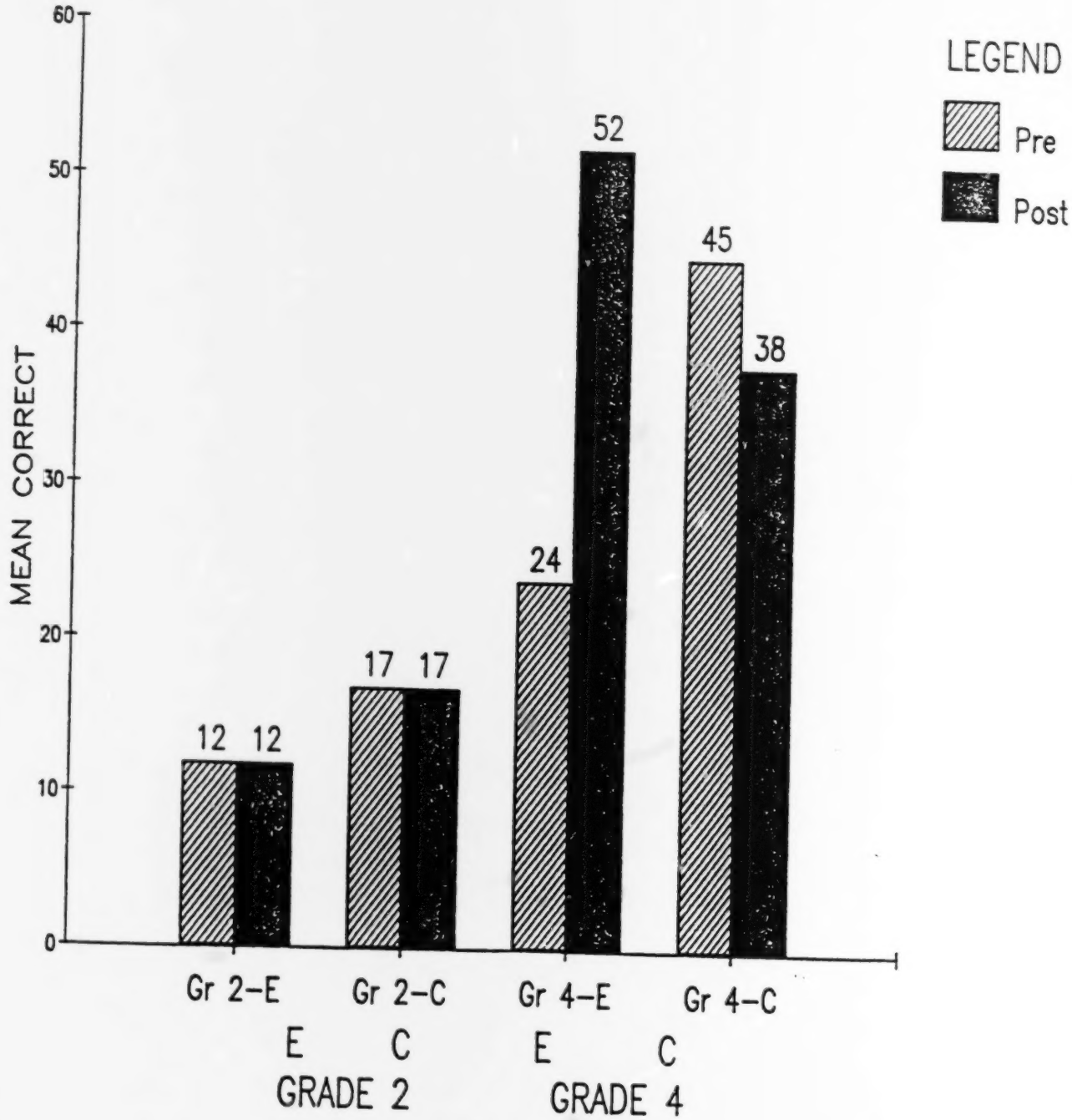
[3] Rotate: 40 items referring to 180°, 90° and acute turns. Puppet should be used as frame of reference.

Figure 2: Mean Pretest and Posttest Right/Left Map Scores by Grade and Treatment (in percentages)



no rotation involved

Figure 3: **Mean Pretest and Posttest "Hard" Map-Reading Scores by Grade and Treatment (in percentages)**



Hard=Up/Down, Acute and Rotate; 40 items altogether.